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SEASONAL MOVEMENTS AND DISTRIBUTION PATTERNS OF A REINTRODUCED CALIFORNIA BIGHORN SHEEP HERD FOLLOWING TRANSPLANT IN THE SIERRA NEVADA, CALIFORNIA

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Abstract: Seasonal movements of 18 radio-collared California bighorn sheep (*Ovis canadensis californiana*) were monitored for 2 years following reintroduction in the Sierra Nevada, California. During the first year, summer and winter ranges were < 1 km apart. Rams remained with ewes on the summer range and herd movements were restricted to an area of 3 km^2. The second year, summer ranges of ewe groups remained approximately the same size but were displaced up to 7 km from the winter range. Rams greatly expanded their movements the second year; their range encompassed all of the areas used by the widely scattered ewe groups. Increased knowledge about the process of home range formation can assist managers planning future reintroductions.

California bighorn sheep originally occupied the Sierra Nevada wherever suitable rocky terrain with access to wintering areas existed (Jone 1950). Population numbers rapidly declined in the late 1800's apparently from overhunting, competition for forage with domestic sheep, and diseases transmitted by domestic stock (Buechner 1960, Wehausen 1980). Distribution in the Sierra currently is limited to 6 populations. Native herds of this subspecies have survived at Mt. Baxter, Sawmill Creek and Mt. Williamson (Wehausen 1980, C. D. Hargis, Unpubl. memo to the Sierra Nevada Bighorn Sheep Interagency Advisory Group, Inyo Natl. For., Lee Vining, 1986). Recent reintroductions of native California bighorn have been made at Wheeler Crest (1979), Mt. Langley (1980) (Andaloro and Ramey 1981) and Lee Vining Canyon.

On 5 and 6 March 1986, 27 California bighorn sheep were captured on the eastern slopes of Mt. Baxter, Inyo Co., California and transplanted 120 km north to Lee Vining Canyon, Mono Co. The Lee Vining reintroduction was the third such in a long-term program designed to reestablish geographically disjunct populations of bighorn sheep on historic ranges in the Sierra Nevada (Sierra Nevada Bighorn Sheep Interagency Advisory Group 1984).

To evaluate the success or failure of this reintroduction, the National Park Service initiated a 3-year monitoring program at the time of release. Primary objectives of monitoring are to (1) document natality and mortality within the new herd; (2) determine seasonal patterns of distribution and range use; (3) investigate the effects of habitat on survival and reproduction. Here, we report herd movements and distribution in the first 2 years following reintroduction.

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STUDY AREA

The 46 km^2 study area is in the central Sierra Nevada of California, 5 km east of the range's main crest (Figure 1). It is bounded by Lundy Canyon on the north and Lee Vining Canyon on the south, and lies within Inyo National Forest. Elevation ranges from 2188 m at the eastern end of Lee Vining Canyon to 3758 m atop the summit of Mt. Warren.

The only significant human development in the area is State Highway 120 which winds along the north side of Lee Vining Canyon. Embankments along the 2-lane highway are used extensively by sheep throughout the year.

Weather on the study area is characterized by cold, harsh winters and warm, dry summers. Annual precipitation averages 69 cm per year and falls primarily as snow deposited between November and April. In 1986 and 1987, snowfall in Lee Vining Canyon was 150% and 25% of normal, respectively.

Low elevation winter ranges (2180-2590 m) support a pinyon-juniper woodland (Munz and Keck 1959). Summer ranges include two distinct plant communities: subalpine forest and alpine fell-field (Munz and Keck 1959).

METHODS

We installed radio collars equipped with mortality sensors on 25 of 27 tranplanted sheep at the time of their release. Seasonal distribution and movement patterns were determined by locating all sheep approximately 5 times a week using either aerial or ground based radio telemetry. Between 378 and 560 telemetry locations were recorded for each sheep. We plotted sheep locations on 7.5 min or 15 min topographic maps and recorded them as Universal Transverse Mercator grid coordinates (UTMs) for home range analysis. Home ranges were calculated using the modified minimum area method (Harvey and Barbour 1965).

Whenever possible, radio locations were confirmed by visual observations. During the past 2 years, individual sheep have each been observed between 97 and 230 times each. In addition to noting locations, we also recorded information on behavior, group size and habitat

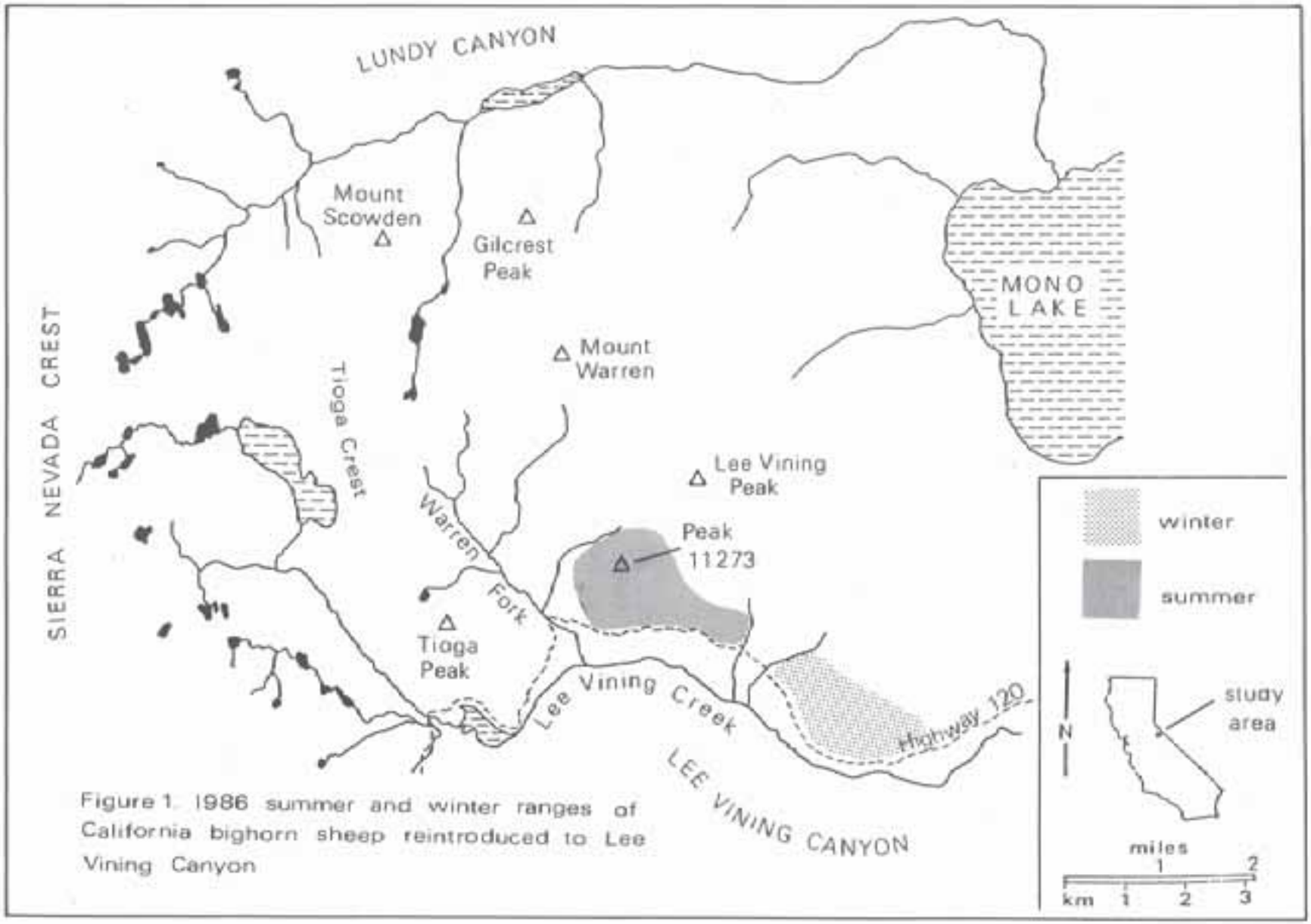

Figure 1. 1986 summer and winter ranges of California bighorn sheep reintroduced to Lee Vining Canyon

characteristics. Fecal pellets and associated bedsites also provided information about the location of use areas.

RESULTS

Twenty-seven California bighorn sheep were transplanted to Lee Vining Canyon (13 ewes, 7 rams, 3 female and 4 male lambs) and released in two groups (n = 14, 13) on successive days (5, 6 March 1986). Following the release, a series of severe storms swept the area and contributed to the deaths of 7 sheep. Between storms, surviving sheep moved down canyon in bands of 2 to 4 individuals. By 1 April, bands had coalesced to form a cohesive herd in the easternmost cliffs of Lee Vining Canyon. They remained there until late May (Figure 1). Individual ewes began to move up canyon to lamb in the third week of April but rejoined the herd on winter range following parturition.

Movement to spring range began in late May as ewes formed nursery bands. The herd remained on spring range for approximately 3 weeks and during that time, movements were restricted to a 0.5 km^2 area. Migration to summer range in the last week of June was abrupt. On the morning of 25 June 1986, 2 ewes left spring range and moved 2 km up canyon. They rejoined the herd at 1400 that afternoon and after 10 minutes of milling about, headed back up canyon followed by most of the herd. During the next week, the herd moved up through the south facing gullies of Peak 11273 and eventually arrived at what became their summer range (Figure 1).

A few individuals did not follow this general pattern. The most significant deviation was the foray by 2 rams into Yosemite National Park. In mid-May, 3 rams departed with winter range and moved 3.5 km up Lee Vining Canyon. Two of these rams crossed Warren Fork Canyon and traversed Tioga Crest. By mid-June they were in Yosemite National Park, 19 km west of the release site. Both rams returned to Peak 11273 on 14 July 1986 and rejoined the main herd, which had moved into that area.

Summer range was utilized from early July until mid-October 1986. During this time, use was concentrated in 2 core areas. One of these was the embankment along Highway 120. This site appears to be a mineral lick and was utilized repeatedly throughout the summer and autumn. The other core area, on Peak 11273, was used for bedding and foraging. On the basis of telemetry locations and visual observations we calculated summer range to be approximately 3 km^2.

Intermittent storms through September and October resulted in repeated movements between summer and winter ranges. Movements during this period also included what appeared to be exploratory forays. On 2 occasions, the herd suddenly moved 6 km north to previously unvisited areas but returned to the summer range after 2 or 3 days. In November 1986, the herd moved to an area midway between the 1986 summer and winter ranges and remained there until Spring 1987 (Figure 2).

Departure from the winter range in mid-April 1987, was initiated by ewes as they moved to lambing areas near the head of Lee Vining Canyon. The remainder of the herd: 5 rams, a ewe, and 5 yearlings, slowly joined

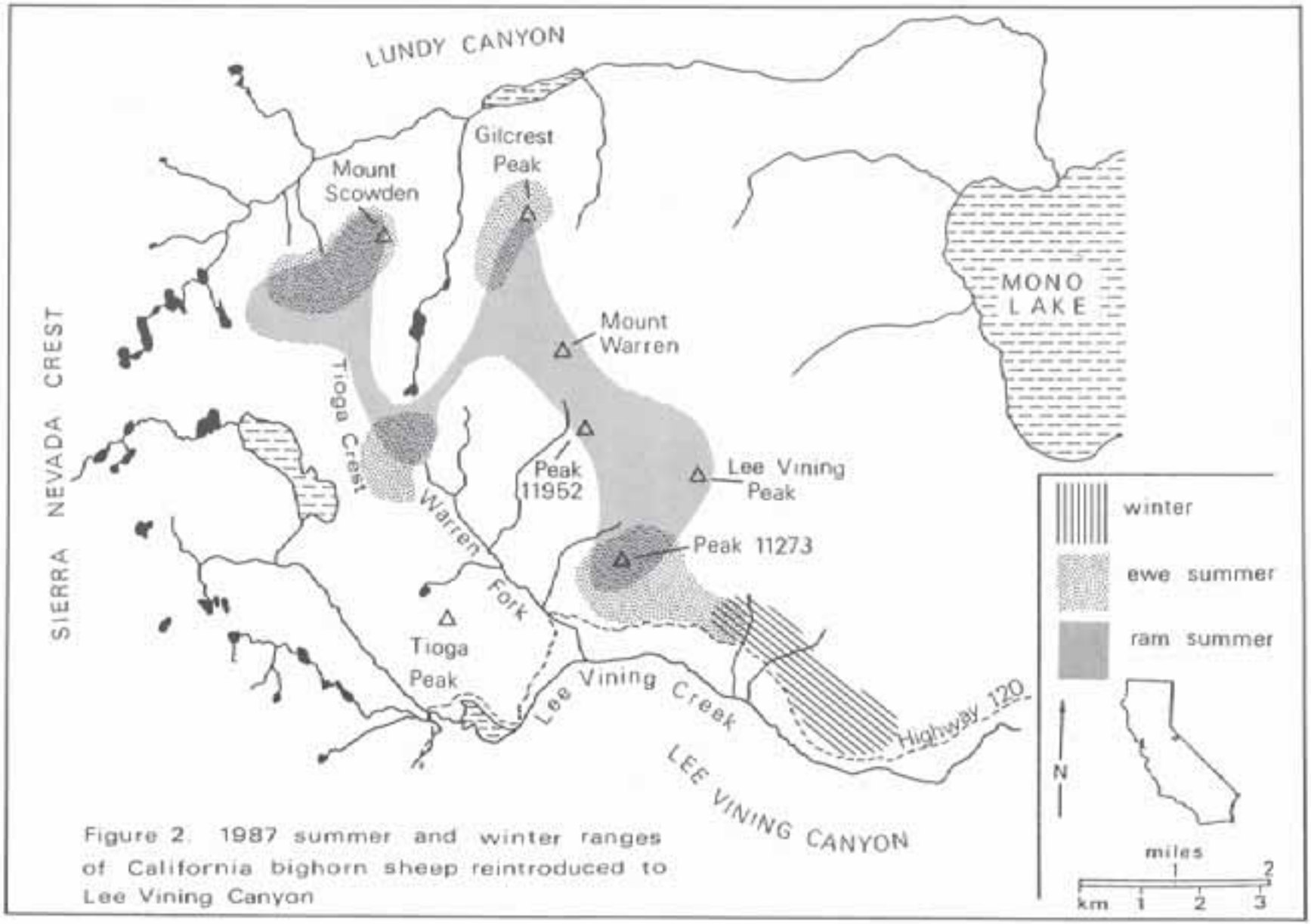

Figure 2. 1987 summer and winter ranges of California bighorn sheep reintroduced to Lee Vining Canyon

them over the next month. Following lambing, herd movements were restricted to 0.5 km^2 around Peak 11273 until late June.

As in 1986, migration to summer ranges was sudden and swift. On 30 June 1987, 2 ewes and their lambs left spring range heading north. By 7 July they had moved 6 km north of Lee Vining Canyon to the vicinity of Gilcrest Peak. This area had been visited by these ewes briefly during an Autumn 1986 foray. During the next 7 weeks, the band utilized the north and west sides of the peak (Figure 2).

On 6 July 1987, 2 rams, accompanied by a ewe and her lamb, also departed spring range and moved northwest, across Warren Canyon, to Tioga Crest. The rams had visited this area briefly in June 1986 while enroute to Yosemite. The band moved north for 3 days until reaching Mt. Scowden. Telemetry indicated that the band made extensive movements around Mt. Scowden before separating in mid-July. The ewe and lamb remained on Mt. Scowden until late August, confining their movements to the northwest side of the peak (Figure 2), while the rams travelled more extensively.

Not all ewes moved to new summer ranges. Three ewes and 2 lambs remained near Peak 11273 which had served as the herd's summer range in 1986. The center of their activities shifted, however, from the east side of Peak 11273 to a gully system on the peak's south face (Figure 2). The mineral lick along Tioga Road was used intensively and we observed frequent movements between these areas.

Ram migration began prior to the first week in June when 2 rams moved from Peak 11273 to the north end of Tioga Crest. In late July, they joined the rams that had moved to Mt. Scowden. All 4 rams formed a loosely knit band that continued to move between areas occupied by the widely separated ewe bands (Figure 2). Membership in the ram band shifted frequently. In mid-October all 4 rams reunited atop Peak 11952. They remained there until mid-November when they joined the ewe bands on winter range.

In September 1986, 3 ewes and 2 lambs emigrated from Lee Vining Canyon to Bloody Canyon, 13 km south. This band has remained there since that time, spending 2 winters at elevations of > 3100 m. Spring and Summer 1987 also saw range expansion by the Bloody Canyon band to an area of 8 km^2 with the winter range at its core.

DISCUSSION

The Lee Vining herd's restricted range use during the first year appears to be typical of reintroduced herds. On the basis of information from bighorn reintroductions in the United States and Canada, Geist (1971 :121) concluded that transplanted bighorn sheep usually restrict habitat use to areas near the release site. We attributed the Lee Vining herd's restricted movements during the first year to the absence of traditional movement patterns coupled with disorientation in an unfamiliar area.

The degree of movement varied among individuals, however, as evidenced by the rams that forayed into Yosemite National Park and the ewes that moved to Bloody Canyon. This variability of movement has been

reported for transplants of desert bighorn sheep (Ovis canadensis nelsoni) (McQuilvey and Pulliam 1981, Elenowitz 1983, Shaw 1986), Rocky Mountain bighorn (O. c. canadensis) (Bear 1979) and California bighorn (Andaloro and Ramey 1981, Hanson 1984). In a study of reintroduced pronghorn antelope (Antilocapra americana), Goldsmith (1988) attributed the high degree of variability in individual behavior to the expression of phenotypic variation in the absence of a social structure found in established herds. This conclusion may also hold true for reintroduced bighorn sheep.

Long distance migration to seasonal ranges the second year resembled movements by native bighorn populations and contrasted sharply with those of the first year. Geist (1971) proposed that migration patterns of native populations are based on traditions passed down through generations of bighorn sheep. In the absence of tradition, however, other explanations become necessary. Studies in California (Hanson 1984, Andaloro and Ramey 1981), Arizona (Shaw 1986), Colorado (Bear 1979), and New Mexico (Elenowitz 1983) all found that reintroduced sheep expanded their use of new areas during the second year following transplant. This may be attributable to increased familiarity with the region. The ewe's selection of summer ranges in those areas that had been visited previously lends support to this interpretation.

Another possible factor influencing movement patterns may have been differences in snowpack between the first and second year of the study. Snow did not pose a barrier to movements in either year because most had melted by the time the herd reached summer range. The large snowpack of 1986 produced snowbanks which lasted throughout the summer and their effect on the length of the plant growing season may have affected movement patterns. Plant growth in the Sierra Nevada is generally limited by the lack of available moisture (Major 1977). Winter snowpack has a major influence on the length of the growing season by providing water to plants during dry summer months (Billings and Bliss 1959). The large snowpack of 1986 may have allowed the new herd to obtain adequate forage in one location throughout the year. In contrast, 1987's below average precipitation may have necessitated long distance movements in search of food.

Predation may also have played a role in determining movements and distribution. In one instance, we witnessed the herd move to a new core area after being chased by a coyote (Canis latrans). In another case, a ewe-lamb band moved 2 km following the loss of a lamb to a puma (Felis concolor). J. Wehausen (Univ. California, white Mtn. Res. Stn., pers. commun.) observed abandonment of a wintering area by the Mt. Baxter herd when puma predation pressure there was high.

Bighorn sheep originally occurred throughout the Yosemite region but were extirpated prior to 1914 (Jones 1950). Evidence from recovered bighorn skulls indicates that native herds summered along the Sierra Nevada crest (Wehausen 1980). It is hoped that the reintroduced Lee Vining herd will eventually recolonize these areas. Monitoring of herd will continue for at least 1 more year. We expect this information will be useful to managers planning future reintroductions.

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